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(54) Improvements in or relating to supporting cores during investment casting

(57) Pins used to support a core in an investment casting mould are completely assimilated into the matrix of the metal being cast. A pattern having a core located therein by means of metal pins held by the pattern material in engagement with the surface of the core has a ceramic shell mould formed around the pattern with free ends of the metal pins protruding from the pattern. The pattern is removed by melting or otherwise heating leaving the core supported within the shell mould by the pins.The metal pins comprise a material having a surface layer which has a lower melting point than that of the base material of the pin,so that when molten metal is cast into the mould, the surface layer material is easily melted and washed away. The base material of the pin is preferably compatible with the metal being cast, so as to melt and diffuse into it. An example of casting a turbine blade is given, using pins of 80/20 Ni-Cr and a surface layer containing boron.

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Improvements in or relating to Investment Castings

The present invention relates to a method for the location or cores in casting moulds in order to prevent movement of the cores during casting. The method is particularly relevant to the technique of investment casting using ceramic shell moulds.

A well-known technique of core location comprises the steps of making a wax or polystyrene pattern of the article to be cast, the pattern having embedded therein the cores which will eventually be removed to form cavities in the finished article. A multiplicity of metal pins, usually of less than 1.25 mm diameter, are pushed through the pattern until they touch the embedded core. About 3 to 6 mm of the metal pins may be left protruding from the pattern. The pattern is then dipped in a series of ceramic slurry tanks to form a shell mould in known manner. The pattern is eventually removed by melting or burning prior to firing of the shell mould

leaving the mould cavity with the internal core accurately located and fully supported by the metal pins. Such a process is fully described in GB 1,219,527.

Usually the metal pins are made from the same alloy composition as that being cast so that the problem of contamination of the component being cast is minimised. Ideally the supporting metal pins melt into and become an unidentifiable part of the cast article. This method, however, suffers from the drawback that the metal of the pins can suffer from oxidation during mould pre-heating prior to casting. This is especially so with some more recent alloys which do not have such high contents of those elements such as chromium, for example, which confer oxidation resistance on the alloy. A result of oxidation of the metal pins during firing or pre-heating of the mould shell, is that they may not be completely fused into the matrix of the article being cast due to the oxide film. Articles are thus produced containing many potential defects which in some applications, of which gas turbine engine turbine blades is but one example, are unacceptable.

Some workers have used the same technique of core location as above but have used platinum wire pins instead of pins made of the component matrix material.

Platinum has overcome the problems of oxidation and non-fusion into the matrix but is very expensive. In the case of gas turbine alloys the effect of platinum is known to be beneficial, therefore problems of detrimental contamination effects either do not arise or are insignificant.

Another technique with reduces the cost of the pin material is to use a relatively cheap base material such as nickel-chromium or molybdenum, for example, and to plate the base material with an oxidation-resistant metal such as platinum.

Yet another approach may be to reduce the melting temperature of the pins themselves relative to the temperature of the molten metal being cast. A problem with this is that the pins may melt too quickly and allow the core to become dislodged or that they may begin to melt during pr-heating of the mould and again allow the core to become displaced.

According to the present invention a method of making an article having a cavity therein comprises the steps of making a pattern having a core contained therein, locating the core relative to a subsequently formed shell mould by means of metal pins held by the pattern material in engagement with the surface of the core,

forming a shell mould around the pattern and free ends of the metal pins protruding from the pattern, removing the pattern by melting or otherwise heating, casting molten metal into the cavity so formed wherein the metal pins comprise a material having a surface layer which has a lower melting point than that of the matrix material of the pin.

The term "pins" is intended to include any shape of metallic element used to locate a core within a pattern or mould. The term "chaplet" is often used to describe such elements. Chaplets formed from sheet metal or expanded metal mesh are known.

It has been found that pins having a lower melting temperature surface layer are assimilated into the matrix of the cast material without leaving any residual trace of the pin. Because of the lower surface melting temperature the oxidised outer layer is relatively easily flushed away by the incoming molten metal leaving behind a clean unoxidised pin surface which is easily assimilated into the component matrix.

In one embodiment of a method according to the present invention the base pin material comprises a nickel-chromium alloy and the lower melting point surface layer is provided by means of diffusing boron

into the surface. The use of nickel base alloy and boron is particularly suitable for the production of many gas turbine engine components as these elements are frequently used in their manufacture and thus contamination is kept to a minimum.

Other base materials may of course be used and such materials may include iron-based alloys, cobalt-based alloys, molybdenum and many others. The actual material may be chosen to be compatible with the alloy of the component being cast.

In the case of borided nickel-chromium alloy pin material a content of 3 wt% boron in the surface layer may depress the melting point to about 1100°C or lower. This may be too low for many applications. A boron content not exceeding 1.5% is preferred and more preferred still is a boron content of about 1 wt% which depresses the melting point from about 1400°C to about 1200°C.

It is important to maintain the total component content of boron below strict limits to avoid depressing the melting point of the component itself.

In order that the present invention may be more fully understood an example will now be described by way of illustration only.

80/20 nickel-chromium wire 0.45 mm diameter and having a surface layer about 0.05 mm thick containing 0.9 wt% boron at the outside was prepared. A wax pattern of a gas turbine engine blade was then produced in a conventional pattern-making machine and having a ceramic core piece embedded therein. Pieces of the borided wire were then pushed while warm through the wax pattern to abut the ceramic core. About 3 to 5 mm of the metal pins were left protruding from the wax pattern. A ceramic shell mould was then formed in known manner thus embedding the protruding ends of the metal pins. The wax pattern was melted out leaving the ceramic core located and supported by the borided wire pins. During firing of the shell mould at temperatures in the range 800 to 1050°C the borided wire becomes oxidised and similarly during pre-heating of the mould to the desired temperature for casting. Once fired the mould is then ready for casting of molten metal to form the required component.

Moulds of turbine blade components having ceramic cores in the root and airfoil portions were prepared in the manner described above for casting trials.

A mould was pre-heated to 1038°C over a period of 8 hours. It was then placed in the chamber of a vacuum casting furnace and IN100 (trade mark) alloy at 1490°C was cast into the mould in known manner and allowed to solidify under vacuum. After cooling and removal from the mould the components were sectioned in the regions where pins had been used. No trace of any support pins were found, the matrix alloy having the normal structure expected.

Similar casting trials were conducted with other alloys including C1023 (trade mark) at metal casting temperatures ranging from 1475°C to 1525°C. No trace of residual pins were found in any of the cast samples.

CLAIMS

1. A method of making an article having a cavity therein, the methcd comprising the steps of making a pattern having a core contained therein, locating the core relative to a subsequently formed shell mould by means of metal pins held by the pattern material in engagement with the surface of the core, forming a shell mould around the pattern and free ends of the metal pins protruding from the pattern, removing the pattern by melting or otherwise heating, casting molten metal into the cavity so formed wherein the metal pins comprise a material having a surface layer which has a lower melting point than that of the matrix material of the pin.

2. A method according to Claim 1 wherein the pins comprise a metal selected from the group comprising nickel-base, iron-base and cobalt-base alloys.

3. A method according to either Claim 1 or Claim 2 wherein the surface layer of the pin contains boron.

4. A method according to any one preceding claim wherein the pin surface layer contains up to 3% of boron.

5. A method according to any one Claims 1 to 3 wherein the pin surface layer contains up to 1.5% of boron.

6. A method according to any one of Claims 1 to 3 wherein the pin surface layer contains up to 1% of boron.

7. A method substantially as hereinbefore described with reference to the accompanying specification.

8. A turbine component when cast by the method of any one of Claims 1 to 7.

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